NASA TT F-8579

GPO PRICE $ ____________

CFSTI PRICE(S) $ ____________

Hard copy (HC) $1.00

Microfiche (MF) .50

ff 653 July 65

NASA TT F-8579

info [redacted]

[redacted]

# LANDING GEAR FOR NOSE-WHEEL EQUIPPED PLANES [* ]

auth.
Nov. 1963 7 p Transl. into ENGLISH by
Holman (John F) and Co. from

[redacted]

Translation of *"Velivolo con carello di ruota di prua" from
Italian Patent No. 409.389, February 11, 1945

FACILITY FORM 602

| | |
|---|---|
| N66 27188 (ACCESSION NUMBER) | (THRU) |
| 7 (PAGES) | 1 (CODE) |
| (NASA CR OR TMX OR AD NUMBER) | 02 (CATEGORY) |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. November 1963

1602812

# LANDING GEAR FOR NOSE-WHEEL EQUIPPED PLANES[1]

Landing and takeoff procedures require that airplanes land and takeoff against the wind. This requires large airstrips and it is often necessary for planes to land and takeoff from limited size runways. This is difficult and dangerous during crosswinds, particularly during short gusts because the lateral thrusts cause the craft to veer from its course and carry it over the narrow runway. With suitable maneuvering and wheel brake application it is possible to counteract this lateral displacement. However, great skill is required since only a minimal amount of time is available for the operation and with a violent wind blowing on the side of the craft, it is clearly impossible to prevent its being driven off the narrow runway.

To eliminate this danger, previous attempts have been made to make the wheels of the plane controllable, and it has been proposed that prior to landing, the pilot, with the aid of a measuring instrument that permits determination of the plane's angle of drift, adjust the wheels of the craft in such a way that they coincide with the direction of travel, whereby in touching the runway the wheels can rotate without introduction of lateral stresses. It has also been proposed that tail-wheel planes employ a drag skid behind the center of gravity to counteract the known tendency of such planes to veer from their direction of movement. In nose-wheel planes which stabilize themselves because the said wheel is freely orientable, this supplementary device is dispensed with. To control the airplane during oblique landings on a narrow runway, it has been further proposed that control of the nose-wheel be allowed for.

All these devices for control entail a relatively high cost of construction and do not lead to a solution of the problem; namely of being able to land and takeoff without danger on a narrow runway during cross winds. The operating conditions of such planes roughly approximate those of the modern automobile. In this case the dangers are known and demonstrated. During side winds, particularly with unexpected gusts, the vehicle careens without warning and this danger increases with increasing speed. At high speeds the vehicle can run over the verge before the driver can correct it by steering action.

The speeds of landing and takeoff for planes are relatively high, and the pilot can counteract the lateral drift of the craft only after a certain reaction time has elapsed (moments of disorientation).

[1]Translation of Italian Patent No. 409,389, Class VIII, to Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren an der Techn. Hochschule Stuttgart, of Germany; application filed 5 July 1943; patent granted 11 February 1945; printed June 1946 [Priority claimed in Germany as of 23 November 1940]

Since in the case of large craft the wheels could not be directly controlled manually, the shift brought about by the suggested controls would still be delayed as a result of the lag due to operation of the mechanism by a servomotor, acceleration of the wheel mass, overcoming of frictional resistance and play. Thus, the landing operation in side winds poses grave problems for the pilot with such controls at his disposal and the problems are not always resolvable.

During a steep descent, the danger of crashing is particularly great because according to the proposals previously advanced, the pilot must adjust the wheel of the plane in the direction of the determined course with the aid of a drift indicator apparatus. Thus there is added another problem to the multiplicity of observations to be made by the pilot during landing. With an erroneous or insufficiently precise adjustment of the wheel, a dangerous lift occurs that can be compared roughly to the condition of an automobile lifted by unevenness, and subsequently falling back onto the road at an angle in relation to the direction of travel.

The previously proposed means of enabling a plane to land on a narrow runway during crosswinds cannot therefore in any circumstance be regarded as simple or safe.

The invention relates therefore to the problem of making the landing, takeoff and taxiing of airplanes on restricted runways and in cross winds safe, and achieving an automatic elimination of the disturbing effect of the wind impinging on the side of the craft, so that even in most difficult circumstances the pilot can land with the same precision as on a large airfield in a direction counter to that of the wind. The novel conformation of the airplane and its landing gear also facilitates takeoff on a restricted runway in a direction which is at an oblique angle to or perpendicular to that of the wind.

Substantially, the invention is based on the fact that in the nose-wheeled airplane, with the said wheel freely orientable, i.e., designed as a drag wheel but damped at peak load, the point of application of the resultant of the lateral forces in the aircraft on level ground is located in one vertical plane and subsequently the force passes through the geometrical axis of the principal wheels, which are not orientable.

The schematic shows in plan view how the lateral forces of the wind act on the airplane, in one instance when the craft is constructed in the usual manner, and in another instance in which it is designed in accordance with the invention.

Figure 1 shows an airplane with standard landing gear, equipped with a tail wheel.

Figure 2 shows an airplane with nose-wheel landing gear.

Figure 3 shows, in four positions assumed successively by the airplane in landing and designated I-IV, the effect of the conformation and of the nose-wheel arrangement of the invention.

Figure 4 shows in four successive positions, designated I-IV, the effect of a later improvement of the invention.

In the landing gear shown in Figure 1, with tail wheel (a) in which the axis of the principal wheels (b) must be located before the center of gravity (s) to prevent nosing over of the plane in taxiing, a wind at angle $V_r$ which is generated by the combined effect of wind (V) produced by the airplane and side wind (S) (see diagram of velocity, Figure 1) produces a resultant which can again break up into a force acting in the longitudinal direction of the airplane and in a lateral path (P) perpendicular thereto. The lateral thrust not only causes the airplane to veer, but it also causes a rotation which substantially is around the principal wheels (b). Tail wheel (a) which generally is free to move, is not in a position to prevent these rotations because it cannot absorb any lateral thrust.

If the effective side wind component assumes the direction of arrow (p) and if the point of lateral thrust application (l) is behind the center of gravity (s) of the craft (as is usual and necessary for stability), the airplane will be turned in the direction of arrow (q). The plane will be rotated against the wind in proportion to the intensity of the side wind and will therefore be forced off the runway.

In the nose-wheel landing gear recently developed (Figure 2) the center of gravity of the airplane must be located ahead of the principal wheels (b). The forward positioned center of gravity (s) stabilizes the airplane.

The craft has a tendency to travel linearly unless there is a predominant side wind. A lateral wind thrust (p) will produce a rotational movement around the principal wheels (b) and therefore the airplane will turn, this time in the direction opposite to that indicated in Figure 1, thus jeopardizing the rate of travel because the nose wheel is either free to move or damped only for transitory vibrations and cannot transmit notable lateral forces.

The problem now consists in preventing the generation of an aerodynamic moment by a gust of cross wind and consequent turning of the airplane around the guide wheels. This is attained if in the airplane (constructed in accordance with aerodynamic conditions and having a precisely determined center of gravity and a determined point of application behind the center of gravity for the aerodynamic force acting on its side) the fixed landing gear is so placed that center of gravity (s), as

Fig. 1

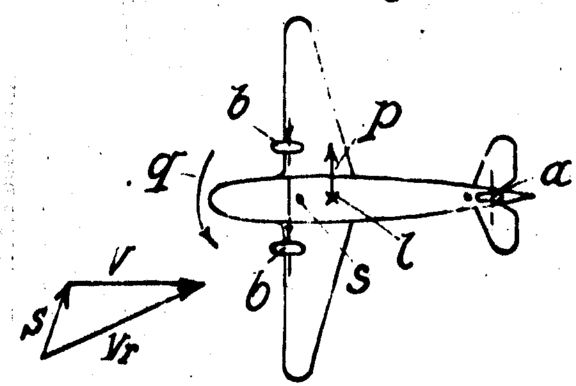



Fig. 3

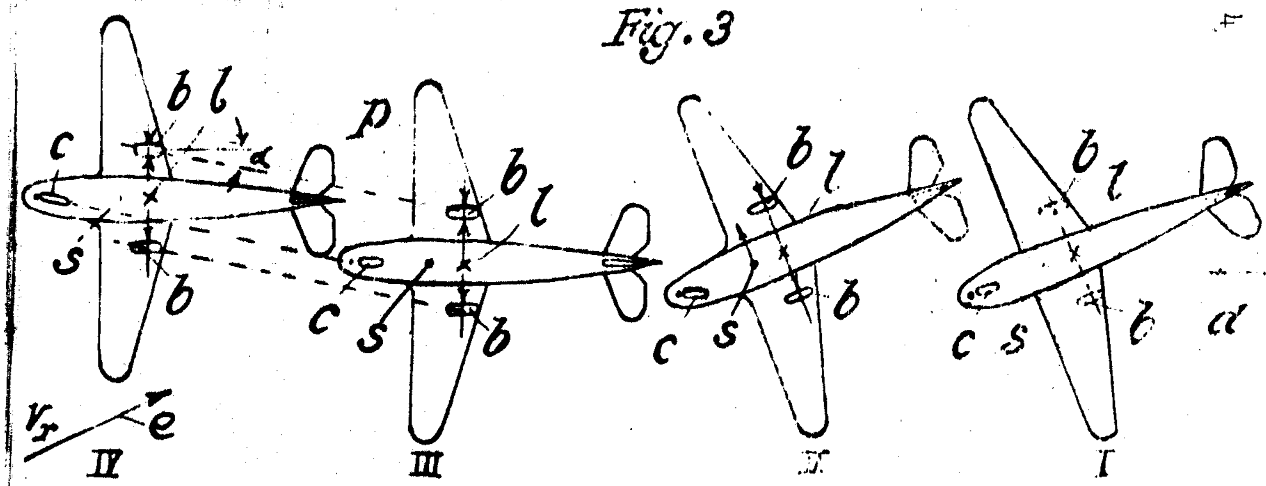



Fig. 2

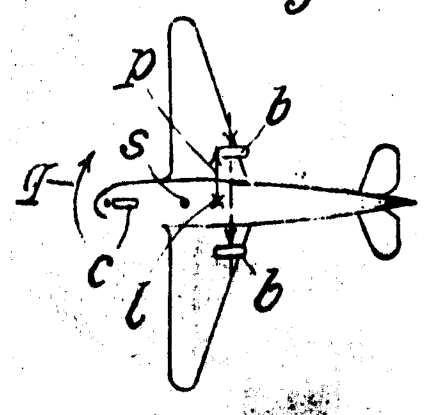
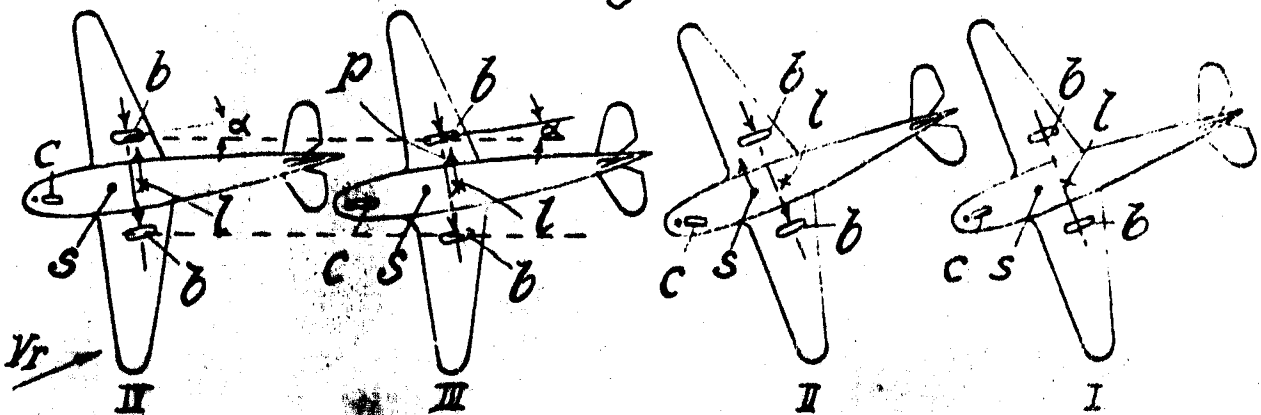



Fig. 4




Figures

required in this model, is located before the point of contact of the principal wheels (b) with the ground, and the point of application of the lateral aerodynamic thrust falls on the geometric axis of the said principal wheels.

Then the airplane can no longer be rotated by the force of the cross wind as in the arrangement of Figure 2, but at most it can be moved parallel to its course because of a lateral thrust exerted upon the principal wheels (b). Figure 3 illustrates this behavior.

In position I the airplane is still airborne in the direction of motion indicated by arrow (d) which corresponds to the direction of the narrow landing strip. This is however placed as required against the direction of the wind designated by arrow (e).

The plane has just touched ground when the lateral thrusts developed in relation to principal wheels (b) in unison with the components of force acting in the direction of movement (e) tend to turn the airplane in direction (d). The freely movable nose wheel (c) in this case is an insignificant factor in inhibiting the displacement.

With position II there is represented an intermediate position for the moment of first contact with the ground, while position III illustrates the final orientation in the direction of the landing strip. The lateral thrust of the wind, because it is applied at a point (l) which is in the center of axis (b) of the principal wheels, can no longer cause the airplane to rotate as in Figure 2, but only moves the plane parallel to its course from position III to position IV with skidding of wheels (b).

If this lateral movement occurs very swiftly, the mass force acting upon center of gravity (s) which is located forward produces a rotation of the airplane in the direction of wind (e) and thereby a partial compensation of the lateral skidding. The pilot can counteract slow displacement with relative ease and safety by adequately adjusting and braking the wheels.

Thus according to the invention the turning of the airplane in the direction of the wind can be attained automatically and with greater security, and the crabbing motion of the airplane can be avoided to a sufficient degree if the axis of the principal wheels (b) is moved still a little farther forward and thus ahead of the point of application of aerodynamic thrust (l) (Figure 1).

In landing the same phenomena are manifested as shown in positions I and II of Figure 3. Here the plane does not orient itself entirely in the direction of the runway, but under the effect of the couple originating from the side wind, it is rotated by angle $\alpha$ into position III against wind (e) and this rotation can attain such a value that it eliminates the crabbing effect mentioned above, so that therefore the airplane is borne automatically from position III to position IV and thus maintains its position on the narrow runway.

With this arrangement the airplane is thus unaffected by the cross winds when the plane is in motion. Even when conditions prevail that differ from those for which this novel arrangement of landing gear was conceived, the harmful effect of the cross wind will be at least so much reduced and slowed that the pilot will have sufficient time to correct the course by operating his controls. Landing will then be effected without danger, even with side gusts.

Consequently, according to the invention, a substantial increase in landing and takeoff security is attained, and it becomes possible to use less elaborate airfields.

CLAIM

Airplanes with nose-wheel landing gear, the said nose wheel being free, characterized in that the point of application of the resultant of the lateral forces due to the air in the case of an airplane on level ground is located in one plane and that the said force subsequently passes vertically through the geometrical axis of the principal wheels (b) which are not orientable.

Translated for the National Aeronautics and Space Administration by John F. Holman and Co. Inc.